



MODELLING WORKLOAD ON THE BISON C3I COMMAND POST: PHASE I - TASK ANALYSIS

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Abstract

This report presents a knowledge base for the creation of a Bison Command, Control, Communications and Intelligence (C3I) Mobile Command Post (MCP) simulator in the Defence Research and Development Canada – Toronto’s (DRDC-Toronto) Noise Simulation Facility (NSF). The purpose of this paper is to provide suitable MCP information such that the study of enhancements to communications, situation awareness, and hearing protection can be made. This knowledge base was established through a limited-scope literature review, a vehicle inspection, Subject Matter Expert (SME) interviews, a compiled inventory of Bison MCP equipment, and an analysis of the tasks performed by a MCP radio operator. Recommendations for MCP simulations include maintaining the highest level of fidelity possible between the lab-based model and the real-world; lab subjects should be trained signal operators and should be recruited from land force personnel (regular or reservist.) Representative MCP tasks would include cordon and search operations and IED scenarios. Operator assessments should be limited to 20 minutes in duration and should include approximately 40-50 messages, of which 5 should be deemed critical. A measure of operator performance may include a mock-briefing of a commander with all relevant intelligence reports or the updating of a map board or both.

Résumé

Le présent rapport constitue une base de connaissances pour la création d'un simulateur de Bison C3I de type poste de commandement mobile (MCP) dans l'installation de simulation de bruits de RDDC Toronto. Le but du présent article est de fournir des renseignements adéquats concernant le poste de commandement mobile avec suffisamment de détails pour que l'étude des améliorations à la communication, de la connaissance de la situation et des protections pour les oreilles puisse être effectuée. Cette base de connaissances a été établie à l'aide d'une recherche documentaire à portée limitée, d'une inspection de véhicule, d'entrevues faites avec des experts, d'un inventaire du matériel du Bison de type MCP et d'une analyse des tâches réalisées par un opérateur de radio de poste de commandement mobile. Les recommandations concernant les simulations de poste de commandement mobile comprennent le fait de maintenir le plus haut niveau de fidélité possible entre le modèle expérimental (*lab-based model*) et la réalité; les sujets de laboratoire doivent être des signaleurs ayant une formation et être recrutés parmi le personnel de la Force terrestre (Force régulière ou Réserve). Les tâches représentatives s'appliquant au poste de commandement mobile comprennent les opérations de recherche, les opérations de ratissage et celles où l'on doit faire face à des dispositifs explosifs de circonstance. Les évaluations par l'opérateur doivent être limitées à 20 minutes et doivent comprendre environ 40 à 50 messages, dont 5 doivent être jugés d'importance capitale. Une mesure du rendement de l'opérateur peut comprendre le breffage (*mock-briefing*) d'un commandant avec tous les comptes rendus de renseignements pertinents ou la mise à jour d'une carte (*map board*), ou les deux.

Executive Summary

This report represents the culmination of a developed knowledge base for the creation of a Bison Command, Control, Communications and Intelligence (C3I) Mobile Command Post (MCP) simulator in the Defence Research and Development Canada – Toronto's (DRDC-Toronto) Noise Simulation Facility (NSF). One of the main goals of this paper is to provide suitable MCP information with sufficient detail such that the study of enhancements to communications, situation awareness, and hearing protection can be made. The knowledge base was established through a limited-scope literature review, a vehicle inspection, Subject Matter Expert (SME) interviews, a compiled inventory of Bison MCP equipment, and an analysis of the tasks performed by a MCP radio operator.

The Bison Command, Control, Communications, and Intelligence Mobile Command Post is an armoured vehicle originally designed as an infantry section carrier. Manufactured by General Dynamics, the MCP variant of the Bison Armoured Vehicle has a raised roof to accommodate various radio suites. There are three blast seats inside the vehicle as well as a bench seat, computer workstations and map boards. The Bison MCP can accommodate 4 crew plus a maximum of 7 passengers. The Bison C3I MCP simulator will require the development of a physical and auditory facsimile vehicle environment. Depending on the fidelity required, the Bison C3I physical environment could be simply represented by three side by side workstations in a plywood mock-up.

A review of current and available literature on command post simulation, design and layout of command posts, and communication performance in command posts was performed. This literature review was limited to a maximum of five articles in accordance with the statement of work.

A vehicle inspection occurred at the National Research Council's Centre for Surface Transportation Technology (NRC-CSTT) on 19 March 2009. While no radio systems were installed in the Bison MCP during the inspection, the intended spaces and headsets were observed.

On 20 May 2009 consultants from *Humansystems*® Incorporated traveled to CFB Petawawa to meet with the crew of a Bison MCP that had just returned from being deployed in Afghanistan. The crew provided valuable information in regards to how the vehicle was tasked by the Task Force Commander as well as the individual assignments of the crew within the vehicle. Further, the Master Corporal signaller provided insight into the auditory and visual demands required of his position.

An equipment inventory and task analysis were completed after having performed the vehicle inspection and SME interviews. Given the fact that exercise observation was not performed, no radios were in situ during the vehicle inspection, and the one crew interviewed had been assigned to the Task Force Commander, the nature of the equipment inventory and task analysis is inherently limited. It was noted that there was a severe discrepancy between the equipment issued in the Bison MCP and the equipment used in-country by the SME operators interviewed. The equipment inventory covered both auditory and visual displays and controls, personal listening and communications devices, command post artefacts, and other visual displays mentioned as being critical to the Bison MCPs mission but unobserved during Vehicle Inspection or SME Interviews. Task analysis covered radio communications, digital communications, reporting of information, and miscellaneous tasks. In addition, the ambient noise levels, auditory and visual demands, and typical task breakdown during stationary and non-stationary event scenarios are described.

Personas were developed after the SME Interviews. This task was completed with limited scope as only one partial Bison MCP crew was available for interview. The typical user assignments of the Bison MCP as well as those user assignments for the Bison MCP crew interviewed are presented. A detailed list of the minimum qualifications needed to work as a MCP signaller is also presented.

It is recommended that in order to maximize the applicability of results obtained from any laboratory experiment, as much fidelity is maintained between the lab model and the real-world setup. Laboratory subjects should be trained signal operators and should be recruited from land force personnel (regular or reservist.) Scenarios should be dual task in nature with the primary task being the monitoring of important radio channels and the secondary task being the monitoring of a further auditory demand or a visual demand. A representative MCP task would utilize cordon and search operations and IED scenarios. Operator assessments should be limited to 20 minutes in duration and should include approximately 40-50 messages, of which 5 should be deemed critical. A measure of operator performance may include a mock-briefing of a commander with all relevant intelligence reports or the updating of a map board or both.

Sommaire

Le présent rapport représente le paroxysme d'une base de connaissances développée pour la création d'un simulateur de Bison C3I de type MCP dans l'installation de simulation de bruits de RDDC Toronto. L'un des buts principaux du présent article est de fournir des renseignements adéquats concernant le poste de commandement mobile avec suffisamment de détails pour que l'étude des améliorations à la communication, de la connaissance de la situation et des dispositifs de protection pour les oreilles puisse être effectuée. La base de connaissances a été établie à l'aide d'une recherche documentaire à portée limitée, d'une inspection de véhicule, d'entrevues faites avec des experts, d'un inventaire du matériel du Bison de type MCP et d'une analyse des tâches réalisées par un opérateur de radio de poste de commandement mobile.

Le Bison C3I de type MCP est un véhicule blindé conçu, à l'origine, comme véhicule de transport de sections d'infanterie. Fabriquée par General Dynamics, la variante poste de commandement mobile du véhicule blindé Bison comporte un toit surélevé pour accueillir divers ensembles radio. Il y a trois sièges anti-explosions dans le véhicule, ainsi qu'une banquette, des postes de travail informatisés et des cartes (*map boards*). Le Bison de type MCP peut accueillir 4 membres d'équipage et 7 passagers. Le simulateur de Bison C3I de type MCP nécessitera le développement d'un environnement identique sur le plan physique et sur le plan sonore. Tout dépendant de la fidélité requise, l'environnement physique du Bison C3I pourrait être simplement représenté par trois postes de travail côte à côte dans une maquette en contreplaqué.

Une recherche documentaire courante et disponible portant sur les simulations de postes de commandement, la conception et l'aménagement de postes de commandement et la communication dans les postes de commandement a été effectuée. Cette recherche documentaire s'est limitée à cinq articles conformément à l'énoncé de travail.

Une inspection de véhicule a été effectuée au *Centre de technologie des transports de surface du CNRC* (CTTS-CNRC) le 19 mars 2009. Alors qu'il n'y avait aucun système radio dans le Bison de type MCP lors d'inspection, les casques d'écoute et les espaces prévus pour ces systèmes ont été observés.

Le 20 mai 2009, des consultants de Humansystems[®] Incorporated se sont rendus à la BFC Petawawa pour rencontrer l'équipage d'un Bison de type MCP qui venait de revenir d'un déploiement en Afghanistan. L'équipage a fourni des renseignements de valeur sur la façon dont le véhicule s'est vu confier une mission par le commandement de la Force opérationnelle et sur les tâches individuelles de l'équipage dans le véhicule. De plus, le signaleur caporal-chef a précisé les exigences visuelles et auditives de son poste.

Un inventaire de matériel et une analyse de tâche ont été effectués après l'inspection du véhicule et les entrevues avec des experts. Étant donné qu'aucun exercice n'a été observé, qu'aucune radio n'était sur place au cours de l'inspection du véhicule et que l'équipage interviewé avait été assigné au commandant de la Force opérationnelle, la nature de l'inventaire du matériel et de l'analyse de tâche est intrinsèquement limitée. On a remarqué qu'il y avait une grande différence entre le matériel réglementaire du Bison de type MCP et le matériel utilisé au pays par les opérateurs experts interviewés. L'inventaire du matériel couvrait les commandes et les systèmes d'affichage visuels et sonores, les dispositifs de communication et d'écoute personnels, l'équipement de poste de commandement et les autres systèmes d'affichage visuels mentionnés comme étant d'importance capitale pour la mission du Bison de type MCP, mais non observés pendant l'inspection du véhicule ou les entrevues avec des experts. L'analyse de tâche couvrait les communications par radio, les communications numériques, la communication de renseignements et diverses tâches. De plus, les niveaux de bruit ambiant, les exigences sonores et visuelles et la répartition de tâches typique lors de scénarios portant sur des événements stationnaires ou non stationnaires sont décrits.

Des postes ont été créés après les entrevues avec des experts. Cette tâche n'a été complétée qu'en partie, car un seul équipage partiel de Bison de type MCP était disponible pour l'entrevue. Les tâches typiques assignées aux utilisateurs du Bison de type MCP, ainsi que les tâches assignées à l'équipage du Bison de type MCP interviewé, sont présentées. Une liste détaillée des qualifications minimales nécessaires pour travailler comme signaleur de poste de commandement mobile est aussi présentée.

On recommande, afin de maximiser l'applicabilité des résultats obtenus par n'importe quelle expérience en laboratoire, de conserver une similitude aussi grande que possible entre le modèle expérimental et le montage réel. Les sujets de laboratoire doivent être des signaleurs ayant une formation et être recrutés parmi le personnel de la Force terrestre (Force régulière ou Réserve). Les scénarios doivent être à double tâche, la tâche principale étant la surveillance de chaînes radiophoniques importantes et la tâche secondaire étant la surveillance d'une exigence visuelle ou d'une exigence sonore supplémentaire. Les tâches représentatives s'appliquant au poste de commandement mobile comprennent les opérations de recherche, les opérations de ratissage et celles où l'on doit faire face à des dispositifs explosifs de circonstance. Les évaluations par l'opérateur doivent être limitées à 20 minutes et doivent comprendre environ 40 à 50 messages, dont 5 doivent être jugés d'importance capitale. Une mesure du rendement de l'opérateur peut comprendre le breffage (*mock-briefing*) d'un commandant avec tous les comptes rendus de renseignements pertinents ou la mise à jour d'une carte (*map board*), ou les deux.

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1. Background

Canadian Forces personnel working as operators in Mobile Command Posts (MCP) are subject to competing auditory and visual attention demands in an adverse noise, vibration, and stress environments. Bison armoured vehicles are currently being refurbished as modular Command, Control, Communications, and Intelligence (C3I) MCPs - see Figure 1. The Bison C3I MCP is equipped with communications equipment, internal workstations, and enhanced armour protection to support battlefield operations. This project seeks to develop a knowledge base for the creation of a Bison C3I MCP simulator in the Defence Research and Development Canada - Toronto (DRDC-Toronto) Noise Simulation Facility for the study of enhancements to communications, situation awareness, and hearing protection.

The Bison C3I MCP simulator will require the development of a physical and auditory facsimile vehicle environment. Depending on the fidelity required, the Bison C3I physical environment could be represented by three side by side workstations in a plywood mock-up. In order to properly assess enhancements to communications, situation awareness, and hearing protection operator tasks, functions need to be identified. Operator tasks and functions are typically identified through behavioural task analysis.



Figure 1: Bison Command Post

Task analysis is a structured method for analyzing the design and training requirements of an item of equipment based upon the operator's goals and tasks that the equipment is intended to support (MOD Defence Standard 00-250, 2008). Task analysis thus describes what a user is required to do in terms of actions and/or cognitive processes to achieve a goal. Task analysis is used to support activities such as function allocation, interface design, work design, and training design. One tenet of task analysis is only go to the level required as task analyses can be very expensive and time consuming to perform.

1.1 List of Acronyms

The following acronyms will be used throughout this project:

ANR	Active Noise Reduction
C3I	Command, Control, Communications, and Intelligence
CF	Canadian Forces
CPU	Central Processing Unit
DND	Department of National Defence
DRDC-Toronto	Defence Research and Development Canada - Toronto
EPLRS	Enhanced Position Location Reporting System
GSM	Government Supplied Material
HSI®	Humansystems Incorporated
LAV III	Light Armoured Vehicle III
MCP	Mobile Command Post
MOD	Ministry Of Defence
NRC-CSTT	National Research Council - Centre for Transportation Technology
PRR	Personal Role Radio
SME	Subject Matter Expert
SOP	Standard Operating Procedure
SOW	Statement of Work
TA	Task Analysis

1.2 Government Supplied Material

From the Statement of Work (SOW) DRDC-Toronto was to ensure access to government personnel as Government Supplied Material (GSM) for interviews and to collect data from. Unfortunately, it was not possible to provide the necessary GSM in a suitable time frame to allow the execution of all tasks of this project. Exercise observation was not completed as no suitable training exercises using the Bison C3I could be located during the project schedule. Recruiting MCP operators and SMEs also proved to be a difficult task. The DRDC-Toronto military liaison worked to coordinate operator and SME interviews in conjunction with the vehicle inspection; however, no such interviews could be arranged during the initial project time frame. As a result of not observing an exercise or conducting interviews, a detailed task analysis and many other requirements of this project could not be completed. An interview with three MCP operators was arranged for May 20, 2009. An extension to the project into the 2009-2010 fiscal year was obtained; however funding could not be carried over from the previous fiscal year and limited new funding was available. As a result, funding became a limiting factor in performing the tasks. Furthermore, results of the interview with MCP operators did not fully support the project direction as originally envisioned as operators were not using many of the Bison C3I equipment.

1.2.1 Bison C3I Mobile Command Post

The Bison Command, Control, Communications, and Intelligence Mobile Command Post is an armoured vehicle originally designed as an infantry section carrier. Manufactured by General Dynamics, the MCP variant of the Bison Armoured Vehicle has a raised roof to accommodate various radio suites. There are

three blast seats inside the vehicle as well as a bench seat, computer workstations and map boards. The Bison MCP can accommodate 4 crew plus a maximum of 7 passengers. Electrical power is supplied via an Onan Quiet Diesel Generator. During stationary operations, the vehicle air conditioning unit is powered by the engine running at high-idle. The vehicle itself is a wheeled 8x8 powered by a 275 hp Detroit Diesel engine. The Bison MCP weighs 13 tonnes and is capable of travelling at a maximum of 100 km/h.

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2. Aim

The aim of this project is to develop a knowledge base for the creation of a Bison C3I MCP simulator in the Defence Research and Development Canada - Toronto (DRDC-Toronto) Noise Simulation Facility.

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3. Methods

A knowledge base to determine the requirements for a Bison C3I MCP simulator was developed through studying the Bison C3I MCP vehicle, a literature review regarding auditory and visual demands in mobile command posts, a vehicle inspection, subject matter expert (SME) interviews, an equipment inventory, and a behavioural task analysis.

3.1 Literature Review

In accordance with the statement of work, the literature review performed was limited to a maximum of five articles. A list of relevant key words was generated and, in collaboration with Array Systems Computing Inc., public access and governmental (classified and unclassified) libraries and databases were investigated. Databases searched included the Defence Technical Information Center (DTIC), the Defence Research and Development Canada (DRDC) library as well as several public-access websites (e.g. Google, GoogleScholar, PubMed). The table below presents the keywords used to search for relevant literature pertaining to simulation of the Bison C3I Mobile Command Post.

Table 1: Keyword List

Core Concept	Primary Keywords	Secondary Keywords
Mobile Command Post	Command post Mobile command post Bison command post	Design, layout, workspace, accessibility, guidelines, task analysis, usability, operator roles, input parameters, output parameters
Application Area	Primary Keywords	Secondary Keywords
Operational Input	Auditory	Input, stress, overload

Primary keywords or phrases are presented vertically; ‘command post’ is a keyword separate from ‘mobile command post’. Secondary keywords are separated by commas. Search criteria were run by pairing a primary keyword with any of the secondary keywords.

Given the need for brevity, the review was organized into Command Post Simulations, Design and Layout, and Communication Performance. These subsections highlight the processes, benefits and limitations of simulating command post operations in a laboratory environment, auditory demands or operator performance, and functional design consideration such that operator performance is maximized.

3.2 Vehicle Inspection

On 19 March 2009 Humansystems[®] consultants visited National Research Council - Centre for Surface Transportation Technology (NRC-CSTT) to inspect a Bison C3I MCP. No radio systems were installed in the MCP during the vehicle inspection; however, the intended spaces and headsets/speakers for the radios were observed. During the vehicle inspection the consultants had the opportunity to informally interview a NRC-CSTT technician, Mr. Doug Bannerman. Mr. Bannerman is retired from the Canadian Forces (CF) where he worked for many years in the signals community. At NRC-CSTT, Mr. Bannerman is involved in the physical and electrical integration of new equipment into the Bison C3I. Mr. Bannerman guided the consultants through the MCP and offered valuable insights to the MCP equipment, employment, use, and staffing.

3.3 SME Interviews

On 20 May 2009 Humansystems® consultants visited Canadian Forces Base (CFB) Petawawa to interview MCP operators with the Royal Canadian Dragoons. One operator was a Master Corporal (MCpl) signaller with radio operator training at CFB Wainwright. Another operator was a Chief Warrant Officer vehicle crew commander. The third operator was a Master Corporal air sentry.

3.4 Equipment Inventory

A detailed list of CF Bison C3I MCP-issued equipment was gathered during the Vehicle Inspection at NRC-CSTT; a list of the equipment that was actually used in the field was compiled after the SME Interviews at CFB Petawawa. Further, a list of equipment described as being critical to MCP operations by the SMEs but not observed during the SME Interviews or Vehicle Inspection is presented.

3.5 Task Analysis

After meeting with SMEs, an analysis of routine and non-routine tasks was generated. These tasks are broken down into radio communications, digital communications, reporting of information, and miscellaneous tasks.

3.6 Personas

This task was completed with limited scope as only one partial Bison MCP crew was available for interview. The typical user assignments of the Bison MCP as well as the user assignments for the Bison MCP crew interviewed are presented. A detailed list of the minimum qualifications needed to be a MCP signaller is put forward.

4. Results

In the following sections, the results for the literature review, equipment inventory, and task analysis are presented.

4.1 Literature Review

In accordance with the statement of work, this brief literature review is limited to a maximum of five (5) articles. It is divided into three subsections: Command Post Simulations, Design and Layout, and Communication Performance.

4.1.1 Command Post Simulations

Of the five sources reviewed, one was categorized as offering advice on command post simulations.

4.1.1.1 *“Issues and Solutions for Command Post Simulations” – Stytz and Banks (2006)*

In this paper Stytz and Banks (2006) describe command post modelling as being in a state of infancy with a lack of foundational research hindering attempts to assess command post teams, technologies and decision making processes. This paper describes the authors’ experiences with assessing individual and crew tasks within a simulated command post. They contend that modeling individual- and team-related workload in command posts is a complex, multi-factorial endeavour with many obstacles to extrapolating laboratory results to the real-world.

The biggest challenge to performing laboratory-based command post experiments was found to be the very nature of the simulation: matching real-world command post settings with those that are available within the model. Experimentation is recommended to mitigate and address some the challenges to efficient network-centric-warfare command post operations. Previous research has shown that the greater the fidelity between the modeled environment and the model, the better the results can be extrapolated and applied toward the bigger picture. Other issues with command post simulation arise, generally from differences in a) number and expertise of personnel, b) technology and equipment, and c) command and communication abilities and technology. More specifically, the authors identify three typical shortfalls encountered when designing command post simulations:

1. Matching the command, control and communications environment that exists in the real-world,
2. Matching the actual size and composition of the command posts that are simulated, and
3. Creating a scenario that is of sufficient length and intricacy to assess the command post team’s response to real-world stress, human task overload, individual expertise, and complexity.

The authors note that the above constraints limit the ability to assess individual performance but do not inhibit the assessment of factors that can improve team performance within the command post.

Other obstacles to maximizing simulation fidelity include, but are not limited to, low numbers of simulation participants expert enough to perform the tasks appropriately. This leads to decreased statistical power, participant motivation, team competency, and the differences in mental states between a real-world command post scenario and the laboratory modelled equivalent. The authors state that the single-most critical aspect to ensure simulation-to-real-world fidelity is the mental model of the battle space held by each person in the command post. Even though the obstacles to conducting a study on command post simulations are many, they are not insurmountable if the experiments are properly designed and if the conclusions drawn are appropriate in light of the fidelity of the command post simulation environment.

With the goal of improving command post performance through more timely and accurate actions and decisions, the authors suggest asking two questions to drive the process of experimentation:

1. Which command and control structure and process results in the best anticipatory response to precursor events?
2. Which command and control structure and process best deals with managing/controlling the response to precursor events and to events themselves?

The authors state that there are four factors of any command post experiment that must be considered:

1. Sensors,
2. Intelligence reports,
3. Network/communications devices, and
4. Personnel decision making.

Of the four factors above, the strongest inter-dependent relationship is between intelligence reports (#2) and personnel who perceive the environment, make decisions, and take action (#4). The other factors are mostly independent. The intelligence-decision making relationship can be further isolated into the following two cases: a) how can the factors (sensors, human perception, cognition, event correlation) that affect decision-making be improved upon, and b) how can the decision-making process itself be improved?

In an attempt to address the issues associated with simulation-to-real-world fidelity as well as the two intelligence-decision making cases, the authors suggest that all command post simulations should do the following:

1. Focus experimental design around the two intelligence-decision making cases
2. Assess the flow, quality, and quantity of information
3. Attempt to be as equivalent as possible to real-world command post team expertise, numbers and task load in key aspects, and
4. Attempt to match the equipment available in the command post being simulated.

Research suggests that both individuals and teams are subject to distraction and process interruption; teams have been shown to recover more quickly and often than individuals. However, because teams require a greater need to communicate and relay shared information as well as a common understanding of the state of task accomplishment, they are more prone to catastrophic breakdowns in communication. With respect to the mobile command post scenario, workspace design and layout as well as auditory overload may contribute to increased distractions and, therefore, a higher probability of catastrophic breakdowns in task effectiveness.

Metrics by which command post performance can be evaluated are presented. The metrics are categorized by the type of experimental design chosen and which of two cases of intelligence input are being considered. Experimental designs can examine all of the four factors (sensors, intelligence reports, network/communication devices, and personnel decision making) separately or examine the interconnections between intelligence and decision making. The first intelligence case concerns the ability of the C2 structure and process to correlated event precursors. The second intelligence case concerns the ability of the C2 structure and process to move information. When the four factors affecting command post design are assessed independently and considering how correlates to decision-making can be improved (the first intelligence case), appropriate metrics would include:

1. Elapsed time,

2. Number of participants in the process,
3. Number of extraneous participants in the process,
4. Number of precursor events that are addressed by the C2 structure,
5. Number of alternative explanations for a precursor event that are considered,
6. Criteria applied to determine the significance of a precursor event,
7. The number of times that the explanation assigned to a precursor event by a given C2 structure is accurate,
8. The perceived difficulty faced when determining what a precursor event signifies,
9. The number of times a sensor is re-tasked correctly, the number of times a sensor is re-tasked incorrectly (unnecessarily),
10. The perceived quality of the decision/interpretation, and
11. The overall quality of the decision process.

For the case where the four experimental factors affecting command post design are assessed independently combined with how well the C2 structure and process is able to move information between the command post components that need information (the second intelligence case), appropriate metrics might include:

1. The speed of the movement of information through the command post and C2 structure,
2. The number of people who should have the information but did not get it (directly),
3. The number of people who did not need the information but received it,
4. The information volume,
5. The perceived quality of communication,
6. The number of times that information has to be retransmitted, and
7. The latency between when a re-tasking directive is sent and when the re-tasking is accomplished.

When the experimental design examines the interconnection between intelligence and decision making, metrics are the same for both intelligence cases and include:

1. The elapsed time to make a decision,
2. The perceived quality of a decision,
3. The number of alternative responses considered,
4. The perceived quality of processes employed,
5. The number of people involved in the decision process,
6. The number of extraneous participants in the process,
7. The criteria applied to determine a response,
8. The perceived difficulty of determining the correct response,
9. The number of pieces of information considered when formulating a response,
10. The number of pieces of extraneous information considered when formulating a response, and
11. The overall assessment of the command post's perceived understanding of the battlespace.

Experiments on auditory overload in operators of the Bison C3I MCP should first identify the level of dependence (or independence) of the four experimental factors – sensors, intelligence reports, network/communication devices, and personnel decision making) and next identify which type of intelligence input is to be analyzed (the ability of the C2 structure and process to correlated event precursors or the ability of the C2 structure and process to move information). These decisions will necessarily lay out the metrics by which both individual- and team-performance can be measured. In the interest of maintaining simulation-to-real-world fidelity, the same number of experimental participants should be used as are in the Bison MCP. An attempt to match the interior environment of the MCP should be made; as well, designing a test scenario that is of sufficient duration and intricacy to assess the command post team's response to real-world stress, human task overload, individual expertise, and complexity would lead to stronger results.

4.1.2 Command Post Design and Layout

Two sources concerning command post design and layout proved relevant.

4.1.2.1 “Workspace Design Handbook for Standardized Command Posts” – US Army Research Institute for the Behavioral and Social Sciences (1990)

This handbook recommends design techniques, assessment approaches, sample operational considerations, human factors guidelines as well as implementation advice for the design of US Army tactical command posts. The material presented is based on subject matter expert (SME) experience and knowledge.

The authors make the point that because a command post is a dynamic workspace, the command post designer should emphasize function and how effectively equipment and space will be used rather than form and the static arrangement of equipment. They recommend the following design criteria in order of priority:

1. Primary visual tasks,
2. Primary controls associated with the primary visual tasks,
3. Control and display relationships,
4. Sequence of operation (left to right; top to bottom), and
5. Consistency of layouts.

The final design should allow suitably clothed users of the 5th to 95th percentile to view, operate, manipulate, remove or replace any item.

The authors strongly recommend that distractions be minimized in the group workspace so as to mitigate breakdowns in information relay. Such distractions, they cite, could be caused by attention getting signals from nearby blinking indicator lights or audible signals on radio or computer equipment. Shielding unnecessary auditory signals or cues is a recommended design implementation.

Competing design factors arise when considering interpersonal communication. Common work areas promote the flow of information among people with proximity of location establishing communication among staff; however, common work areas may also lead to unwanted interferences and distractions during tasks performed simultaneously. The ability of both individuals and teams to filter salient, transferrable information from noise is paramount. “Noise” can be defined in this context as any auditory or visual stimulus that does not need to be relayed. The authors suggest that a network analysis would help determine work locations based on priority of function and the required proximity to produce the desired frequency and quality of communications among pairs or groups of staff.

The auditory environment in command posts should be controlled at a level high enough to ensure effective communication and low enough to minimize distraction. This handbook states that for frequent telephone or radio use or frequent communication up to 5 feet, noise should not exceed 65 dBA since the level of typical speech at 5 feet is approximately 60 dBA; at levels close to this limit the listener would be straining to hear and speaker volume should be adequately adjustable to mitigate the strain while still maintaining noise security. For required communications up to 15 feet, noise should not exceed 55 dBA. The authors state that when noise is approximately 65 dB at 25 meters, the signal can be identified by enemy forces as far away as 2000 metres.

Noise can and should be attenuated by staggered placement of sound deflecting and absorbing materials such as doors, corridors and bulkheads. When several channels are to be monitored simultaneously by means of loudspeakers, the speakers should be a minimum of 10 degrees apart in the horizontal plane ranging from 45 degrees left to 45 degrees right of the operator's normal forward facing position.

The authors state that proximity of workspace location can lead to operator distraction and command post dysfunction. The space separating the middle and rear workstations of the Bison C3I MCP is approximately 95 mm; additionally, the space separating the Athena workstation from the middle workstation is 457 mm. The close proximity of these work areas may lead to interruption and distraction among the crew of the MCP. Furthermore, given the limited overall space within the Bison MCP as well as the communications nature of its intended use, an effort should be made to maintain noise levels at 65 dBA so as to maintain operator comfort and communications security.

4.1.2.2 Analysis and Layout of Artillery Command Posts – Phase I Final Report including Phase II Plan – Humansystems Inc (1996)

This document reviews and evaluates mobile command post interior designs and proposes new design concepts to accommodate possible changes in crew structure, equipment and interaction among crew members. Vehicles analyzed include the M577 with 5 crew members, the M113 with 3 crew members and the Light Support Vehicle Wheeled (LSVW) with 5 crew members. The composition of a five person crewed mobile command post would typically include the Regimental Command Post Officer (RCPO), two Signallers, one Technician and one Driver

In their report, the authors state that important auditory links exist between all team members but those between each Signaller and the RCPO are particularly important. Several design constraints were identified, the biggest constraint being unable to reconstruct the vehicle container itself. A partial list of other design constraints follows:

- The mounting systems for the radio racks and speaker systems are immovable,
- Noise levels will vary based on outside activity and the volume of radio traffic, and
- Vibration will exist under movement, therefore, all headsets and speakers must account for this noise as well as all computers and hardware must be suitably insulated from this low frequency mechanical stress

If possible, experiments on auditory overload among the crew of the Bison C3I MCP should strive to include a vibrational input. This paper suggests that the low-frequency noise associated with vibration under movement may attenuate the radio operator's ability to consistently and effectively monitor radio communications.

4.1.3 Communications Performance

The final two review sources were categorized as concerning communications performance.

4.1.3.1 Evaluation of Radio Communication in Dismounted Infantry Sections – Humansystems Inc (2005)

This report sought to determine whether the addition of a radio would improve the communication and performance of an 8-soldier section. More specifically, this paper highlights what aspects of communication and performance are enhanced or inhibited by the use of infantry intra-squad radios.

Results of this study revealed that orders were the most common type of communication followed by information transfers both with a radio and without. In terms of network configuration, the most traffic was generated by a four-person assault group, followed by the leader's network. The average duration of messages was approximately 2.0 seconds through the radio. This study reveals that in team communication situations, having radio communications did not improve team performance and in some contexts actually hindered performance; however, exit questionnaires showed that, in spite of the lack of quantitative data supporting the radio's role in intra-squad communication, overwhelming support was offered by the test participants for the inclusion of a radio.

This paper suggests that amongst the crew of the Bison MCP, the most commonly communicated piece of information will be orders of approximately 2.0 seconds in duration. Given the fact that, as a mobile command post, information from many and various sources will be relayed to and from the Bison C3I, intra-crew communication through the radio may or may not prove to be effectual. This paper also shows that while quantitative data revealed radio communications hindered performance of 4-person teams, qualitative data reported that the users preferred radio communication to communication without radios. This last point is noteworthy because it implies that regardless of the quantitative data obtained, qualitative user testimony is as equally if not more important.

4.1.3.2 Whole-Body Vibration in Military Vehicles: A Literature Review – Nakashima (2005)

This paper reviews the effects of whole-body vibration (WBV) on hearing and cognitive performance in military vehicle personnel. The author notes that with the ever increasing mobility of command and control operations in a given theatre of war, the operators of these mobile command posts are subject to noise and vibration conditions that their counterparts in a static command post are not. Given the already high levels of cognitive and sensory demands on C2 operators, the author attempts to address the challenges of working in this environment through a thorough review of relevant literature.

Whole-body vibration represents an understudied mode of mechanical stress in military personnel. WBV occurs when the body is supported by a vibrating surface as in the case with tracked and wheeled vehicles in the CF. Whole-body vibration is most often associated with frequencies between 0.5 and 100 Hz. The magnitude of vibration is typically represented as acceleration in m/s^2 and expressed as root-mean-squared values as opposed to peak-to-peak. Maximum transmission of vertical vibration to the body has been shown to occur at 5 Hz; human performance has been found to be most affected at this vibration frequency. Vibration levels greater than 2.0 m/s^2 are perceived as "extremely uncomfortable". Vibrations encountered in the real-world are quite often much higher than 2.0 m/s^2 suggesting that prolonged exposure to uncomfortable levels of vibration may distract command post operators or otherwise affect their hearing and cognitive performance.

Vibration has been shown to maximally affect visual acuity and manual tracking performance at 5.6 Hz and at distances less than 1.5 m. Additionally, research suggests that WBV combined with sustained noise tends to exacerbate low-frequency hearing loss in mining, forestry, and lumber industry workers. Temporary threshold shift (TTS) was most effectually induced in subjects wearing ear protection at 5 Hz vibration and at 3.5 m/s^2 given a noise stress of 101 dB; it should be noted that hearing loss as a result of vibration and noise stimulus combined was significantly greater than either condition alone. Exposure to vibration has been shown to accelerate noise-induced hearing loss with implications toward decreased productivity and effective communication. Vibration has not been shown to significantly affect

performance for simple cognitive tasks but may negatively impact more complex tasks. That said, cognitive assessments performed in the M113 during a representative field trial exposed the operators to vertical vibration levels of 0.3 m/s^2 at 12.5 Hz, 6.4 m/s^2 at 4 Hz and 8.6 m/s^2 rms at 3 Hz. This experiment revealed impairment of cognitive performance in complex tasks, when vibration is combined with noise stressors and when the vibration exposure is of long duration. Vibration and noise were shown to have an interactive, but not additive, effect on performance of more complex cognitive tasks. Vibration is concluded to impair cognitive function when the following three conditions are met:

1. The task is complex,
2. Vibration is combined with another stressor, such as noise, and
3. Vibration exposure is of long duration.

All of these conditions may be met in the Bison C3I MCP.

The author indicates that little research has been carried out on the effect of vibration on communication. This is of concern as vibration may have a negative impact on speech intelligibility.

Due to the difficulties in simulating or replicating the vibration forces and profiles experience in the field, the author recommends field testing with the caution that other mediating variables may not be controllable.

The hazardous nature of Bison C3I MCP operations places the vehicle and crew in terrain that may not necessarily be flat or even. This implies that the crew of the MCP will be exposed to various sources of low-frequency noise and acceleration such as when the engine is on and running and when the vehicle is moving over uneven terrain, through the engine running. Based on the results presented in this review, it appears critical that whole-body vibration be included in studies modelling auditory overload, situational awareness, and sustained attention.

4.1.4 Summary

Modelling command posts is a complex, multi-factorial endeavour. Assessing individual performance requires a different experimental protocol than assessing team performance. It is suggested that experiments first look at command post sensors, intelligence reports, network/communication devices and personnel decision making and ascertain how inter-related they are in the situation under study. One of two intelligence inputs should be analyzed next; either a) the ability of the C2 structure and process to correlate event precursors or b) the ability of the C2 structure and process to move information. Defining a command post experiment by these parameters will dictate the metrics by which both individual- and team-performance can be measured. Some other points to consider when designing a command post experiment would be to match the command, control and communications environment in the model as closely as possible to the real-world scenario, match the actual size and composition of the simulated command posts with the real, and create a scenario that is of sufficient length and intricacy to assess the command post team's response to real-world stress, human task overload, individual expertise, and complexity.

The design and layout of command post workstations has been shown to effect operator performance. Too close of a proximity can lead to distraction and interruption and cause a negative impact on cognitive performance; Stytz and Banks (2006) suggest that interruptions in a team environment can be catastrophic. The space separating the middle and rear workstations of the Bison C3I MCP is approximately 95 mm and the space separating the Athena workstation from the middle workstation is 457 mm.

Research presented here suggests that the low-frequency noise associated with vibration under movement may adversely affect the radio operator's ability to consistently and effectively monitor radio communications. The Bison C3I MCP operates in rugged conditions; this fact suggests that vibration

from both the motor running and the effects of the terrain being transmitted through the vehicle will be expose the crew to low-frequency noises and accelerations over sustained periods. Vibration has been shown to maximally affect visual acuity and manual tracking performance at 5.6 Hz and at distances less than 1.5 m and to cause a temporary threshold shift in hearing at 5 Hz and at 3.5 m/s^2 given a noise stress of 101 dB. Furthermore, impairment of cognitive performance in complex tasks was observed when vibration is combined with noise stressors and when the vibration exposure is of long duration. These results indicate that the inclusion of low-frequency noise and vibration when studying auditory overload, situational awareness and sustained attention is a critical factor in maintaining simulation-to-real-world fidelity.

4.2 Equipment Inventory

The second contractor task, in accordance with the SOW, was:

- b. Documentation of equipment (including audio and visual displays and controls, preferably with screen shots) and personal listening and communications devices, and hard copies of artefacts used on the Bison command post, if available.*

4.2.1 Auditory Displays & Controls

Auditory displays and control devices included in the Bison C3I MCP were documented through vehicle inspection and the technician interview. The following auditory displays and controls were noted:

- Radios
- Vehicle Intercom
- Telephone
- User Control Device
- Loudspeakers

Although no radios were installed in the vehicle inspected at NRC-CSTT, the technician indicated the following five radios are included in the MCP:

- RAD-A+ (AN/VRC-513(V))
 - A1
 - A2
- RAD-C (AN/VRC-516)
- RAD-M (AN/VRC-103(V)1)
- Enhanced Position Location Reporting System (EPLRS)

The communications shelf on which the radios are mounted was inspected and radio locations noted - see Figure 2. Limited information was available regarding the radio systems. The RAD-C radio was reported as an HF radio with a fan which may add noise when active, whereas the others were reported to not have fans.



Figure 2: Communications Shelf

The vehicle intercom was another auditory display available to operators in the MCP. Capability to connect to the secure land line using cables was observed as another potential auditory display.

All radios and the vehicle intercom system were routed through the User Control Device (UCD) - see Figure 3. Five UCDs were installed in the Bison C3I; one UCD per workstation, one above the bench seat, and one at the crew commander's position. SME operators indicated this UCD was a critical piece of equipment.



Figure 3: User Control Device

Three loudspeakers were also spread throughout the MCP, with one above the bench seat, one above and forward to the Athena workstation, and one above and to the rear of the rear workstation – see Figure 4. The Bison C3I MCP has the capability for additional speakers to be employed, such as when the penthouse is attached to the rear of the Bison C3I – see Figure 5. The loudspeakers can transmit the selected channel of any one of the radios. The power and frequency response of the loudspeakers is unknown. SME operators indicated that the loudspeakers were essential and used more frequently than headsets. Operators noted the limited utility of the option of adding additional speakers through the connection point as they merely added volume to the existing speaker outputs; operators would much prefer to have the ability to add an additional channel to monitor when adding additional speakers.

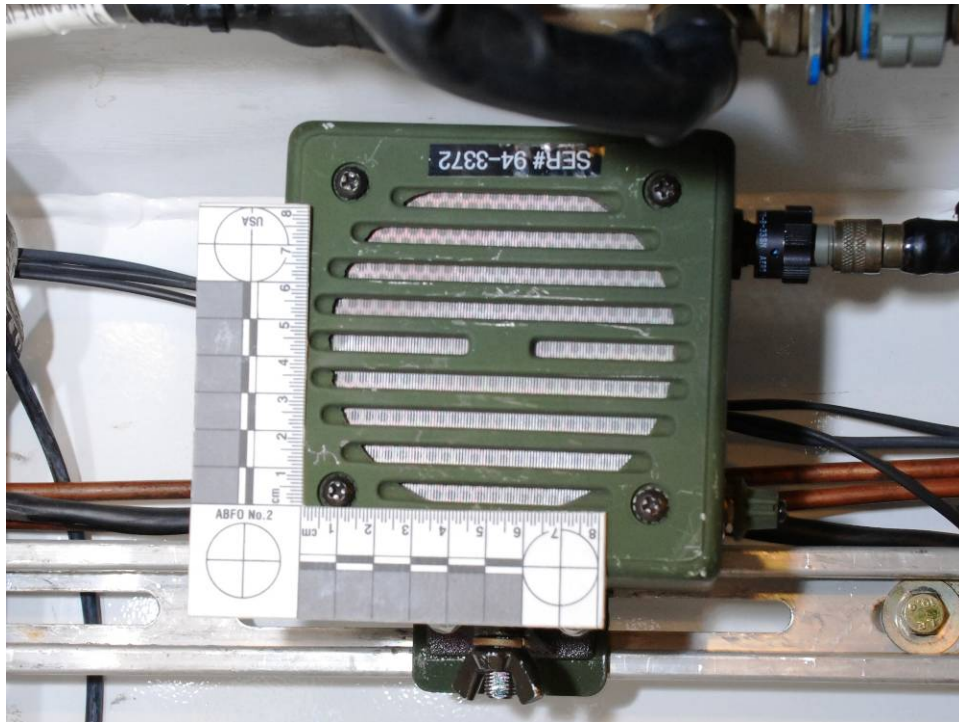


Figure 4: Loudspeaker



Figure 5: Speaker Connection Point

4.2.2 Visual Displays & Controls

The following visual displays and controls were noted during the visit to the NRC Centre for Surface Transportation Technology laboratory:

- Map Boards
- Prosine Control Panel
- Generator Starter
- UCDs - see auditory displays and controls
- Athena Tactical System (ATS) Computer Workstation.

4.2.2.1 Athena Tactical System Workstation

The ATS is an integrated Command and Control (C2) system that provides automation support for commanders and staffs at formation and unit levels for the non-specialist planning, directing, monitoring and control functions. The ATS is an integrated network of computers with specific software. Athena runs on Windows NT. The Bison MCP is currently configured to house one or two Athena workstations.

The Athena computer workstation is the configured workstation in the Bison MCP. The Athena workstation is normally permanently installed - see Figure 6 and Figure 7. The monitor enclosure of the Athena is approximately 508 mm square while the monitor itself measures 406 mm wide by 324 mm high. The width of the Athena desktop (on which the keyboard sits) is approximately 584 mm. Luminance measured at the Athena workstation desktop ranged from 368 lux to 370 lux with the vehicle doors closed and all task lighting turned on. When the task light on the front bulkhead was extinguished, luminance was reduced to 308 lux.

MCP operators indicated that the Athena workstation was removed because it was of limited utility. It should be noted that the ATS is being replaced by BattleView.



Figure 6: Athena Computer Workstation



Figure 7: Athena Computer Workstation Control Details

The middle and rear workstations provide a desktop surface and map boards - see Figure 8. These workstations are identically outfitted and are approximately 95 mm apart. The technician interview revealed that each unit provides laptop computers for operators to use while working at the middle and rear workstations. A convenience power bar is provided between the middle and rear workstations. The workstation itself is comprised of a desktop (approximately 584 mm wide) above which a cork map board is affixed to the curb-side wall. The map board measures 610 mm wide by 419 mm high. Luminance measured at the middle workstation desktop ranged from 399 lux to 442 lux with the vehicle doors closed and all task lighting turned on. When the task light on the behind the middle workstation front was extinguished, luminance was reduced to 399 lux. Luminance measured at the rear workstation desktop ranged from 426 lux to 436 lux with the vehicle doors closed and all task lighting turned on. When the task light on the behind the rear workstation front was extinguished, luminance was reduced to 341 lux. Separation between the Athena workstation and the middle workstation was measured at 457 mm.

SME operators indicated that the workstation desks, blast seats, rifle racks, and map boards were removed due to space constraints. SMEs noted that the map boards were not appropriately sized for the standard map sizes.



Figure 8: Workstations with Map Boards

4.2.2.2 Prosine Control Panel

The Prosine control panel was located behind the bench seat, adjacent to the communications shelf - see Figure 9. The Prosine is a power inverter which provides clean AC or DC power to the Bison MCP. From this panel operators can monitor and control AC information, battery status, inverter mode, charger mode, and system information, a function that the technician indicated would be carried out by the vehicle crew commander or driver.



Figure 9: Prosine Control Panel

4.2.2.3 Onan Quiet Diesel Generator Panel

The generator starter was located on the forward bulkhead - see Figure 10. From this panel the Quiet Diesel generator can be controlled and functioning monitored. SME operators indicated that the generator was one of the best pieces of equipment in the Bison MCP.



Figure 10: Generator Starter

4.2.2.4 Other Visual Displays

The following visual displays were mentioned during SME discussions but not observed:

- **Situational Awareness System (SAS).** The Situational Awareness Module (SAM version 5) of the IRIS Situational Awareness System (SAS) provides a graphical interface supporting situational awareness for the Canadian Army – see Figure 11. SAS currently runs on SCO UNIX. The Bison MCP is currently configured to house one SAS workstation (laptop) for the vehicle commander.



Figure 11: SAS Display

- **BattleView.** The Canadian Army has combined the functionality of the Athena Tactical System with the CGI operational planning application, OPERA (Operational Planning Environment and

Reference Application) in a new system. BattleView is the latest primary command and control (C2) application for the Canadian Army, deployed in battle groups and at higher-level headquarters. BattleView currently runs in a Windows XP operating environment – see Figure 12. OPERA is a multiuser environment providing authoring and calculation tools to support the planning of tasks for the Canadian Forces Operations allowing information exchange based on the NATO LC2IEDM data model and that includes all reference data on resources. It also provides information access on doctrines, organizations, equipment and resources. The Bison MCP is currently capable of housing a ruggedized laptop with the BattleView software loaded.



Figure 12: BattleView on laptop

- **Rover 4.** Rover 4 is a portable receive-only terminal that displays sensor data from multiple airborne platforms – see Figure 13. It supports Ku-band digital, C-band digital, C-band analog, S-band analog and L-band analog signals. The Bison MCP is currently capable of housing a Rover 4 system.

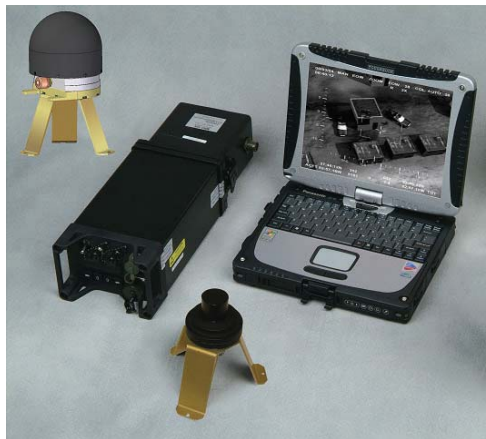


Figure 13: Rover 4system

- **mIRC.** mIRC is a popular Internet Relay Chat client used by the Canadian Forces, to share information between different workstations on Internet Relay Chat (IRC) networks around the world. The Canadian Forces uses mIRC to share logged radio messages, intelligence updates, Intelligence summaries etc. The mIRC interface is detailed in Figure 14. The Bison MCP is currently capable of housing a ruggedized laptop with the mIRC software loaded.

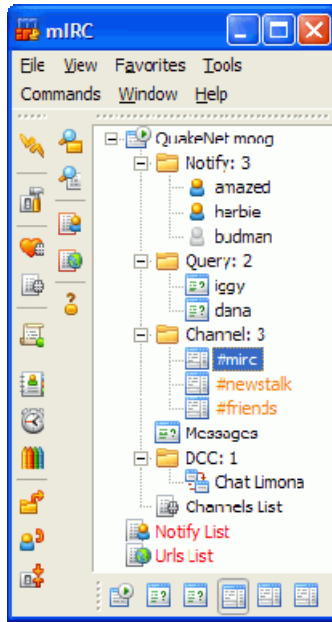


Figure 14: mIRC interface

4.2.3 Personal Listening & Communications Devices

Three variants of headsets were noted as personal listening and communication devices in the Bison C3I MCP. The technician interview indicated that all three headsets were Slingard headsets from Racal Acoustics. The Slingard II provides Active Noise Reduction (ANR) and Talk-Through Capable (TTC) functions in a low profile, muff style headset with a boom microphone - see Figure 15. The technician interview indicated that the Slingard Vehicle Headset is a low profile, muff style headset with boom microphone similar to the Slingard II but without the ANR or TTC - see Figure 16. The technician interview also stated that the Armour Vehicle Headset was an older Slingard product that was still in use - see Figure 17. The muff style headset with boom microphone used mechanical shutters to provide some ambient hearing capability when open.



Figure 15: Slingard II



Figure 16: Slimgard Vehicle Headset



Figure 17: Armour Vehicle Headset

4.2.4 Command Post Artefacts

As the vehicle inspected was not assigned to an operational unit, no operational artefacts were available. The following MCP workspace attributes were observed:

- Workstation Physical Dimensions and Characteristics
- Lighting
- Other Devices

The three workstations were mounted to the curb-side wall of the Bison. Each workstation included an adjustable blast seat with seatbelt (Armatec Survivability Seat, London ON, Part #16760), desktop, map board, UCD, and task lighting. The bench seat ran along the road-side wall of the Bison and included two seats with seatbelts and a backrest, and two addition seats without seatbelts or backrest in front of the communications shelf.

Task lights were installed overhead for each workstation, with three additional lights along the bench seat and communication shelf and one on the front bulkhead - see Figure 18. Black out (blue) lights accompanied each task light, with the exception of the middle bench seat light which did not have a corresponding black out light.



Figure 18: Task Lighting & Black Out Lighting

Other devices noted inside the MCP included:

- MCP compartment vent, located on the ceiling between the middle and rear workstation seats - see Figure 19
- Athena Central Processing Unit (CPU)
- Electronic power distribution unit
- Radio filters
- Communications integration units
- Relay box
- Fire suppression system
- Mounting bracket and location for Land Ethernet Switch (LES) above Athena CPU
- From the SME operator interviews, the user modified Bison MCP included:
 - Folding outdoor chairs
 - Folding table
 - Coffee maker
 - Map tubes



Figure 19: Vent

4.3 Task Analysis

The third contractor task from the SOW was:

- c. Analysis and process maps of routine and non routine tasks including but not limited to demands on auditory and visual channels carried out by crew members. For each task (and subtasks, if applicable) the analysis should include specifications of any devices used by personnel and estimates of ambient noise levels.*

4.3.1 Routine and Non-Routine MCP Tasks

Based on the literature review and discussions with the SMEs, the following MCP tasks were identified:

Establish radio communications

- Start Onan diesel generator (if not from vehicle power)
- Monitor inverter Built in Test (BIT)
- Monitor generator Built in Test (BIT)
- Mount radios in racks
- Attach power cables from power supply units to radio racks (should be completed already)
- Attach power cables from radio racks to radios
- Assemble/erect antenna masts
- Attach antennae cables to antennas and radios
- Attach field telephone cables to rack
- Power up radios/antenna power units

	<p>Monitor radio Built in Test (BIT)</p> <p>Install cryptographic and non-cryptographic keys</p> <p>Review Communication Electronic Operating Instructions (CEOI); to confirm network frequencies</p> <p>Program frequencies and channels</p> <p>Change power settings</p> <p>Perform function test</p> <p>Assign radios to headsets and speakers via UCD</p> <p>Attach headsets to UCD</p> <p>Adjust volume on UCD</p> <p>Adjust speaker volume</p> <p>Establish communication net/ request permission to join communication net</p> <p>Prepare field telephones</p> <p>Connect wire to field phones</p> <p>Connect wire to MCP terminal</p> <p>Switch frequencies upon code word or time</p> <p>Reconfigure which radios to listen to on headset and speaker via UCD</p> <p>Apply transmission security</p>
Prepare for Vehicle Move	<p>Power down radios/antennae power units using masts</p> <p>Disassemble masts</p> <p>Store masts on vehicle exterior</p> <p>Reconfigure appropriate radios from mast antennas to whip antennas</p> <p>Confirm vehicle generated power is available at inverter/listen</p> <p>Shut down generator</p> <p>Monitor inverter</p>
Establish digital communications	<p>Mount computers on racks/workstation tables</p> <p>Attach power cables to computers</p> <p>Attach network cables</p> <p>Power up computers</p> <p>Log on to computers</p> <p>Log on to networks</p>
Monitor radio traffic	<p>Monitor up to 4 radios</p> <p>Determine Call Sign (C/S) of sender</p>

	<p>Identify critical situations which indicate significant changes in the battlefield</p> <p>Record locations and C/S involved in events on signal log</p> <p>Update map board</p> <p>Record contingency plans</p> <p>Monitor units compliance with orders and progress</p> <p>Record progress on battle map board</p> <p>If radio traffic is too dense request for help - focus on key network(s)</p>
Receive radio messages	<p>Determine C/S of sender</p> <p>Identify readiness to receive message</p> <p>Record msg on signal log</p> <p>Acknowledge msg receipt</p> <p>Determine appropriate recipients/action of information directed to C/S</p> <p>Prioritize recipients for the delivery of information</p> <p>Prioritize information for delivery</p> <p>Forward msg to recipients/reply to message</p>
Receive routine radio checks	<p>Check to see if radio or electronic silence has been imposed</p> <p>Review CEOIs for radio check timings (on the hour)</p> <p>Monitor radio checks</p> <p>Send radio check when required</p> <p>Record msg on signal log</p>
Receive routine Location Report (LOCREP) request	<p>Check to see if radio or electronic silence has been imposed</p> <p>Select appropriate map or navigation aid</p> <p>Identify present location</p> <p>Confirm current position</p> <p>Send LOCREP msg</p> <p>Record msg on signal log</p>
Receive routine Situation Report (SITREP) request	<p>(May be an Own Position Situation Report)</p> <p>Check to see if radio or electronic silence has been imposed</p> <p>Select appropriate map or navigation aid</p> <p>Identify present location/ Activity</p> <p>Confirm current position</p> <p>Send SITREP msg</p>

Monitor digital traffic	Record msg on signal log
	(not normally done on the move and if available)
	Observe friendly positions on Battlefield Management System (BMS) (i.e. Athena, BattleView)
	Observe enemy positions on BMS (Athena, BattleView)
	Monitor mIRC
	Identify critical situations which indicate significant changes in the battlefield
	Update map board
	Monitor units compliance with orders and progress
	Record progress on battle map board
	Send routine requests via text
Miscellaneous tasks	Prepare meals/coffee
	Erect/disassemble black-out screen/penthouse
	Stow supplies for transit
	Act as air sentry
	Monitor Rover-4 (if equipped)
	Assist passengers
	Set-up SAT phone
	Set up secure WW access/DWAN access laptop

It should be noted that the tasks identified above were specific to a particular MCP role. The subject matter experts at CFB Petawawa used the Bison MCP in the role of the Task Force Commander's tactical command post. The fact that this particular Bison C3I and crew were detailed specifically to the commanding general of the Canadian Task Force in Afghanistan may represent a limited scope of the use of Bison MCP.

4.3.2 Ambient Noise Levels

Ambient noise level measurements were taken in a warehouse garage using a Martel Electronics (Londonderry, NH) C-322 Data Logger and Sound Level Meter. This sound level meter has a 32-130 dB level range with a dynamic range of 50 dB. Resolution is 0.1 dB and the frequency range is 31.5 Hz to 8 kHz; recording in both the dBA and dBC scales are possible. Ambient noise level measured outside of the rear gate, with the MCP generator running but the vehicle off were approximately 67 dBA and 73 dBC. A series of noise measurements were then taken inside of the vehicle and are reported in Table 2. The first line of measurements simulates operation of the MCP in a static position, without the concerns of light discipline or armour protection. The second set of data simulates the operation of the MCP in a static position, with light discipline and full armour protection. The third set of data simulates the operation of the MCP while on the move. Note that while the vehicle engine was turned on, engine noise was the lowest possible due to low revolutions per minute with the engine idling and the absence of road noise and vibration.

Table 2: Ambient Noise Levels

Workstation	Athena	Middle	Rear
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Condition	dBA	dB	dBA	dB	dBA	dB
Door Open, Generator Running, Hatches Open, Vehicle Off	56.0	82.9	56.0	83.7	55.1	81.6
Door Closed, Generator Running, Hatches Closed, Vehicle Off	55.7	75.5	54.9	79.1	55.5	80.3
Door Closed, Generator Running, Hatches Closed, Vehicle Running	79.4	90.1	77.8	93.1	76.8	90.0

4.3.3 Auditory Demands

During a meeting with a Master Corporal (MCpl) Signaller in the Royal Canadian Regiment (RCR) the auditory demands on tactical command post radio operators were captured. Speakers were preferred above armour vehicle headsets because radio operators could then utilize more than 2 distinct sources to listen to multiple networks (nets). Typically, speakers were tasked accordingly:

Speaker #1	Company net
Speaker #2	Battle Group net
Speaker #3	Head Quarters net
Speaker #4	Internal/Tactical net

The signaller SME that was interviewed suggested the most demanding auditory input came from Speaker #2 channelling the Battle Group net. This single source could, and often did, require one person's sole attention. When the MCP was stationary and/or when troops were in contact, Battle Group communications were such that a second radio operator would be required to monitor the remaining nets.

Given that this particular Bison MCP was responsible to the Task Force Commander, Satellite Communications (SATCOM) capability was considered essential. When the General required it, one of the monitoring speakers would be rededicated to the use of SATCOMs; this point was particularly emphasized when the MCP was on the move and satellite communications became proportionately more important. As well, during engagements with the enemy, the General was known to monitor and direct operations via the satellite-enabled Troops in Contact (TIC) net.

Ambient noise levels were noted as being intrusive while both stationary and on the move. When the vehicle was in motion, low-frequency rumbling from the engine, the tires on the ground, and noise of battle interfered with monitoring auditory inputs.

Mitigating the auditory demands of the radio operators was the absence of any electronic recording system (such as a laptop, ROVER 4, BattleView, etc.) This meant that, in addition, to listening to four distinct auditory inputs, the operator was required to manually log radio communications and to physically update map boards. Again, this was considered a difficult if not impossible undertaking during vehicle motion as well as in the thick of battle. The MCpl Signaller of this Bison MCP was further tasked with briefing the General on all major developments at the Task Force, Company, Battle Group and TIC levels.

It was noted that a typical radio operator shift would last approximately 2 hours before attention and awareness started to drop off. This length of time reflected optimal working scenarios (i.e. stationary vehicle and normal radio chatter). When radio operators felt the workload demands were increasing beyond their capacity, they would call other crew personnel to assist in monitoring channels and logging pertinent information. Using this strategy the radio operator felt that he could adequately manage his workload.

4.3.4 Visual Demands

Bison MCPs are equipped with three worktop desks. One of these workstations is designed to be used in conjunction with the Athena Tactical System while the other two are centred beneath curb-side wall mounted map boards. The crew of the Bison MCP interviewed removed the blast seats, SAS, the Athena Tactical System, as well as the workstation desks and map boards. Operators stated that Athena was an antiquated system and that the chairs and desks were an non-optimal use of space. The blast seats were not as mobile as desired, distinctly lacking the ability to pivot about the vertical axis. Aerial maps of regions patrolled by the Bison MCP were physically larger than the map boards provided, therefore, the map boards proved were not acceptable. The crew stated that no visual display systems were in use negating the reason for maintaining the blast seats and workstation desks.

Ideally, the blast seats would be retained if BattleView or some other visual situational awareness program was made available. In addition to BattleView, the crew stated that other visual awareness modules that would dramatically increase the effectiveness of the MCP while on patrol would include Rover 4 (the UAV video-based software), mIRC (the internet relay chat client for Microsoft Windows), and a dedicated, multi-bootable laptop capable of connecting to secure email as well as logging radio chatter electronically.

If the above ideal conditions were met, the Bison MCP crew stated that two operators would be needed to properly monitor both the audio and visual demands thereby increasing battle effectiveness and awareness.

4.3.5 Scenarios

The MCP crew interviewed were responsible for the Task Force Commanders tactical CP. This mobile CP supplemented the stationary main CP which possessed significant numbers of operators, communication and battle management systems, etc. The role of this CP was to maintain the commander's situational awareness as he moved forward into the operations zone.

Discussions with the MCP crew identified a number of typical operating scenarios:

- Maintenance of communications on the move
- Monitoring combat missions from a static vantage point. The participants identified cordon and search operations and reaction to IED strikes as high signal traffic activities.

4.3.5.1 Maintenance of Communications on the Move

While on the move the signaller monitored the combat nets and also the Headquarters net to identify the local tactical situation. If possible the signaller would update the convoy's position on the battle board if possible. While on the move the signallers would focus their attention mainly on the combat networks. If equipped with a working battle management system like BattleView, the signaller would sit in a blast seat while monitoring the radios and monitoring the lap top. The signaller would record important messages on to a signals log book, field message pad or any other available writing pad. If required the signaller would pass the written message to the commander if the commander was distracted or monitoring other networks and had not heard the message.

4.3.5.2 Cordon and Search Operations

Monitoring the clearing of compounds of interest was stated to be a typical scenario for the stationary Bison MCP. In this capacity the MCpl Signaller would monitor the Battle Group net, the Task Force net, the Vehicle net, and the TIC net over speakers. All arms calls for fire, calls for attack helicopter fire messages, requests for troop movement, reinforcements, resupply, etc. were highly important. Over the course of a standard 2 hour shift, approximately 200 messages would be received. Out of the 200

messages 20 to 40 would be considered highly important and worthy of passing along to the General. These 20 to 40 important messages would include grid references, intelligence reports, and contact reports.

4.3.5.3 React to IED Strike

Monitoring IED strikes or the detection of mine or Unexploded Ordinance (UXO) was a high priority task. All medical 9-liner messages, Casualty Evacuation Requests (CASEVACREQ), were highly important. IED strikes required the dispatch of quick reaction units, repair teams, medical evacuation etc. Supporting and coordinating responses to IED strikes was important due to transmission challenges (from the main base) in the hills and mountains of the operating zone.

4.3.6 Vehicle Modifications

The Bison MCP vehicle and crew under study were assigned to the Task Force Commander in Afghanistan. In this capacity they were required to transport more personnel than typically found in a unit Bison MCP. Passengers would include members of the media, VIPs, interpreters, and the General's aide de camp. Given the equipment and packs that the additional passengers would carry, the availability of free space inside the vehicle was decreased significantly.

To meet the competing demands of workspace furniture and stowage requirements, the crew of this Bison MCP dramatically modified the Bison MCP. The crew removed the blast seats and work tables. Instead they used a folding deck chair and a folding 1 m x 3 m table. When the vehicle was stationary, the signaller would sit on the folding chair to monitor all auditory channels. Full-sized maps would be hung in the area where workstations #2 and #3 were located. Updates to visual situational awareness would be achieved by marking the maps manually. The crew noted that having dedicated tubes for map storage was a design oversight that should be revisited in future design iterations.

4.3.7 Hierarchical Task Relationships

The fourth task from the SOW was:

- d. Determination of the timing requirements for various tasks including the hierarchical relations among tasks, as well as the logical and/or temporal dependencies among tasks, with information maps detailing the flow of information among crew members and from the Bison to other units.*

Without exercise observation determination of the hierarchical task relationships could not be completed. The MCP crew from Afghanistan recommended contacting Canadian Manoeuvre Training Centre (CMTC) Wainwright to acquire communication and situation awareness records from work-up training exercises. They believed all radio traffic, unit position, screen grabs etc. were captured. The participants believed timing data as well as information flow may be recoverable post-hoc.

If previous exercise data is unavailable, then the participants suggested monitoring a Bison MCP during work up training in Canada or during the final pre-deployment exercise in the United States. The participants cautioned that equipment used in Canada may not be functional in Afghanistan (i.e. SAS or Athena) and that some equipment in Afghanistan is more available in theatre than in Canada (i.e. BattleView, Rover 4, mIRC).

The information flow amongst the crew members in the Force commander's MCP was minimal. Typically, the Commander's signaller would monitor the communication networks and up date the commander when appropriate or demanded. If the situation dictated, i.e. high volumes of message traffic over multiple means the duty signaller would either call for help or personnel not on duty but listening to the speakers would know when to come to the signaller's aid. When two crew members were working

together the duty signaller would tell the assistant what radios to monitor. Usually the duty signaller would focus on the TIC net and another combat network.

4.4 Personas

The fifth task from the SOW was:

- e. Development of the personas of crew members including their general capabilities, expertise in particular areas, education and training.*

This task was completed with limited scope as only on one partial Bison MCP crew was available for interview.

From the interview with the NRC-CSTT technician, typical Bison C3I crew composition was identified as having five members:

- Three Staff Officers / Senior Non-Commissioned Officers (SNCO) crew the MCP
 - Unit Operations Officer
 - Warrant Officer Crew Commander
 - Another officer from the unit, typically a junior Captain, to monitor intelligence reports, Rover 4, and the Athena computer workstation
- Vehicle Radio Operator, typically Master Corporal or Sergeant trained in communications equipment
- Driver, typically a Private or Corporal

Staffing of the Bison C3I will vary by unit type (Infantry, Armour, Artillery, Signals) and between units of the same type. The unit commander may sit in the MCP on the bench seat where he/she can monitor and command the unit's activities.

From the interview with the partial crew of the Bison MCP assigned to the General of the Canadian Task Force in Afghanistan, the crew assignments were identified as:

- One Staff Officer
 - Warrant Officer Crew Commander
- One Senior NCO second-in-command (2IC)
 - Sergeant or Master Corporal
- One Senior NCO Vehicle Radio Operator
 - Master Corporal
- Driver and Air Sentry, typically a Private or a Corporal

As this vehicle did was not outfitted with Athena, Rover4, or BattleView, no accompanying intelligence officer was staffed. As well, during times when the Radio Operator was overwhelmed by radio traffic, typically the Air Sentry would be called upon to aid in monitoring channels, updating the battle board and/or logging transmissions.

4.4.1 MCP Signaller

Of particular relevance to this project is the target audience description of the personnel operating and monitoring the MCP command and control systems. Based on discussions with the MCP crew from

Afghanistan the MCP signaller could be any soldier who had acted as a platoon or company signaller. Infantrymen who had been cross trained on the TCCCS Iris radio systems have acted as MCP signallers.

A preliminary review of the target audience thus suggests that the operators of Bison MCP communication systems will primarily be soldiers and Non-Commissioned members of the Land Force. Users will be composed of both genders, different ages, different levels of experience, different native languages (English and French) and anthropometry. Operators will have the following minimum medical profile:

V3 (Vision factor level 3):

- Far Vision
 - Uncorrected vision of up to 6/60 in both eyes.
 - Corrected vision of 6/6 in better eye and 6/9 in worst eye.
 - Refractive error not to exceed plus or minus 7.00 dioptries spherical equivalent in the better eye.
- Near Vision
 - Corrected N5 (in 30-50 cm distance) & N14 (in 100 cm distance) in better eye, N6 (in 30-50 cm distance) & N18 (in 100 cm distance) in worst eye.
 - (Note: N5=0.5m equivalent meter print size, N6=0.6m, N14=2.0m, N18=2.5m)

CV3 (Colour vision factor level 3):

- Colour vision unsafe (Deutan).

H3 (Hearing factor level 3):

- Member has the necessary auditory acuity to hear sounds of less than or equal to 50 dB in either ear in the 500 to 3000 Hz frequency range.

G2 (Geographical factor level 2):

- Member has no geographical limitations due to a medical condition; and,
- Member is considered healthy and, at most, requires only routine and/or periodic medical services.

O2 (Occupational factor 2):

- Member has no employment limitations of a medical nature, on only minor limitations which do not prevent the member from fully meeting the generic and specific occupational (Military Occupational Code (MOC) Task Statements.

A5 (Air factor level 5):

- Assigned to all non-aircrew members of the CF who are medically fit to fly as passengers in CF aircraft

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5. Recommendations

After meeting with the partial crew of a Bison MCP the following recommendations have been developed for DRDC simulations assessing enhancements to communications, situation awareness, auditory demands, hearing protection, and operator tasks:

5.1 Simulation of the Physical MCP Environment

- Confirm the usage of blast seats in the Bison MCP. Anecdotal evidence suggests that other commanders are removing the blast seats and work tables for stowage reasons. If so utilize folding chairs and simple tables as work stations.
- Confirm the switch from ATS to BattleView. Utilize a laptop with BattleView as a visual demand.
- Utilize a laptop with incoming mIRC records to use as a visual demand
- Include a map board with a suitable 1:50, 000 map for updating the operating picture.
- Simulate stationary missions by including the high-idle noise of the engine running an air-conditioner
- Simulate missions on the move (if required) by including low frequency rumbling noise
- Utilize in-service communication gear, radios, UCDs, speakers, etc.
- Utilize 4 speakers with adjustable volumes
 - one above the bench seat at the rear,
 - one above and forward to the Athena workstation location,
 - and one above and to the rear of the rear workstation location
 - One to simulate a radio speaker

5.2 MCP Operators (subjects)

- Recruit trained signal operators
- Recruit land force personnel (regular or reservist) with the minimally required medical profile and sufficient experience
- Scenarios may have a battlefield or operational context that may preclude the use of civilian subjects

5.3 Experimental Approach

- Undertake a conventional dual task experiment
 - there should be resource trade-off with the secondary task sensitive to the resource demands of the primary task;
 - there should be equivalence of single and dual primary task performance; and
 - the secondary task must remain resource sensitive throughout the experiment.
- Examples of dual task load may include

- Primary auditory monitoring task and a secondary visual task
- Primary auditory task – channel 1 and secondary tasks – channels 2 and 3, etc.

5.4 Representative MCP Tasks

- Utilize cordon and search operations and IED scenarios
 - Monitor multiple radios and visual displays
 - Update battle board with critical information
 - Record significant events
 - Brief “commander” on situation/events/locations/etc.

5.5 Potential Independent variables

- Time
 - Limit operator assessments to 20 minute sessions
- Auditory message frequency
 - In 20 minutes, operators should be exposed to 40-50 messages, of which 5 should be deemed critical (intelligence reports, grid references, contact reports)
- Overlapping auditory and visual messages (overlap 2, 3 channels)
- Number of radios and visual displays in use at once
- Speaker configuration – radio assignment
 - i.e. have 3 speaker channels conveying information simultaneously
 - Channel #1 Company information
 - Channel #2 Battle Group information
 - Channel #3 TIC information

5.6 Potential dependent measures

- NASA TLX workload
- Mock brief to the Task Force General whereby all relevant information would be relayed and a mock map board updated.
 - Accuracy of relayed messages
 - Auditory
 - Visual
 - Location accuracy on map board

6. Notes

The technician interview revealed several notable points regarding the use and employment of the Bison C3I not covered in other sections:

- There will be 85 Bison re-roled as the C3I variant
- Units that will be provided with re-roled Bison C3I
 - Infantry
 - Armour
 - Artillery
 - Signals
- Re-roled Bison will be provided at the unit level
- Ballistic curtains will be used inside the Bison C3I MCP which may impact the sound and light levels and acoustic properties.

Note that these points have not been verified by a secondary source.

6.1 Future Opportunities

Discussions during the technician interview suggested that it may be possible to run a small command post exercise at NRC-CSTT with the Bison C3I in their possession with signals operators from the reserve 763 Communications Regiment. Reserve units are often receptive of small taskings such as this, and would have all of the necessary radios to make the MCP fully functional.

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(U) This report presents a knowledge base for the creation of a Bison Command, Control, Communications and Intelligence (C3I) Mobile Command Post (MCP) simulator in the Defence Research and Development Canada – Toronto's (DRDC–Toronto) Noise Simulation Facility (NSF). The purpose of this paper is to provide suitable MCP information such that the study of enhancements to communications, situation awareness, and hearing protection can be made. This knowledge base was established through a limited-scope literature review, a vehicle inspection, Subject Matter Expert (SME) interviews, a compiled inventory of Bison MCP equipment, and an analysis of the tasks performed by a MCP radio operator. Recommendations for MCP simulations include maintaining the highest level of fidelity possible between the lab-based model and the real-world; lab subjects should be trained signal operators and should be recruited from land force personnel (regular or reservist.) Representative MCP tasks would include cordon and search operations and IED scenarios. Operator assessments should be limited to 20 minutes in duration and should include approximately 40–50 messages, of which 5 should be deemed critical. A measure of operator performance may include a mock-briefing of a commander with all relevant intelligence reports or the updating of a map board or both.

(U) Le présent rapport constitue une base de connaissances pour la création d'un simulateur de Bison C3I de type poste de commandement mobile (MCP) dans l'installation de simulation de bruits de RDDC Toronto. Le but du présent article est de fournir des renseignements adéquats concernant le poste de commandement mobile avec suffisamment de détails pour que l'étude des améliorations à la communication, de la connaissance de la situation et des protections pour les oreilles puisse être effectuée. Cette base de connaissances a été établie à l'aide d'une recherche documentaire à portée limitée, d'une inspection de véhicule, d'entrevues faites avec des experts, d'un inventaire du matériel du Bison de type MCP et d'une analyse des tâches réalisées par un opérateur de radio de poste de commandement mobile. Les recommandations concernant les simulations de poste de commandement mobile comprennent le fait de maintenir le plus haut niveau de fidélité possible entre le modèle expérimental (lab-based model) et la réalité; les sujets de laboratoire doivent être des signaleurs ayant une formation et être recrutés parmi le personnel de la Force terrestre (Force régulière ou Réserve). Les tâches représentatives s'appliquant au poste de commandement mobile comprennent les opérations de recherche, les opérations de ratissage et celles où l'on doit faire face à des dispositifs explosifs de circonstance. Les évaluations par l'opérateur doivent être limitées à 20 minutes et doivent comprendre environ 40 à 50 messages, dont 5 doivent être jugés d'importance capitale. Une mesure du rendement de l'opérateur peut comprendre le breffage (mock-briefing) d'un commandant avec tous les comptes rendus de renseignements pertinents ou la mise à jour d'une carte (map board), ou les deux.

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(U) auditory overload; audio visual strategies